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Received: 5 Sep. 2018
Accepted: 19 Nov. 2018
Editor: R. Causse

First record of five fish species from Réunion Island observed during the inventory of the Marine Natural Zones of Interest for Ecology, Flora and Fauna (ZNIEFF)

by

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Résumé. – Premier signalement à La Réunion de cinq espèces de poissons lors de l'inventaire des Zones Naturelles d'Intérêt Écologique, Floristique et Faunistique Marines (ZNIEFF).

Ce papier fait état du premier signalement de cinq espèces de poissons marins pour La Réunion, recensées lors de campagnes d'inventaires de la biodiversité menées dans le cadre des Zones Naturelles d'Intérêt Écologique, Floristique et la Faunistique Marines (ZNIEFF). Ces espèces : *Fusigobius inframaculatus* (Randall, 1994), *Fusigobius neophytus* (Günther, 1877), *Samariscus triocellatus* Woods, 1960, *Trichonotus marleyi* (Smith, 1936) et *Zapogon evermanni* (Jordan et Snyder, 1904) ont toutes été photographiées au sein d'habitats non récifaux, malgré un échantillonnage réalisé sur de nombreux habitats récifaux et non récifaux de l'île présentant un intérêt écologique significatif. Cette étude confirme l'hypothèse qu'un échantillonnage plus soutenu sur les habitats non récifaux et sur les zones profondes de l'île permettrait probablement le recensement de nombreuses nouvelles espèces.

Key words. – Geographic distribution – Range extension – New species – Tropical marine ichthyofauna – Underwater Visual Census – Coral reef.

The fish fauna of Reunion Island has been studied since the 18th century. The sampling effort made to describe these organisms can be considered as very important, given the small surface area of the island and its coral reefs (18 km^2; Nicet *et al*., 2015). The most recent inventory, summarizing all of the work done on Réunion ichthyofauna, was published by Fricke *et al*. in 2009. It reported 984 marine and freshwater species belonging to 164 families.

Since this publication, several papers have completed the inventory, particularly through the work of Quéro *et al*. (2009a, b) Fricke *et al*. (2013, 2016), Pinault *et al*. (2013a, 2014, 2015a), Bourjon and Fricke (2016), and Wickel *et al*. (2016), carried out outside coral reef areas. These recent studies demonstrate that a targeted sampling effort on the less studied habitats often leads to new records and sometimes to the description of new species.

Other studies carried out in coral reef areas show that non-reef habitats have been neglected in recent decades in favour of reef habitats *stricto sensu* (Day *et al*., 2002), which are supposed to be more biodiverse than non-reef habitats (Sale, 1993). Thus, recent lava flows, artificial habitats, sedimentary plains, estuarine areas, pebble beds, rocky reefs, deep cliffs and canyons, but also the ecosystems intimately associated with the coral reefs that are seagrasses and mangroves, today represent subsampled biodiversity reservoirs (Dorenbosch *et al*., 2005).

Letourneur described in 1998 that the "non-reef" habitats of Réunion Island were as rich as the "reef" habitats, notably because of the pronounced deterioration of the coral reefs, favouring the installation of ubiquitous and opportunistic species to the detriment of species specifically associated to this ecosystem. It is with this in mind that from 2015 to 2017, a campaign has been carried out to identify Réunion marine biodiversity on the main marine habitats, reef and non-reef, of ecological, floristic and faunistic interest (ZNIEFF).

During this inventory, five new species of actinopterygian fish were observed and photographed. They are presented in this paper.

MATERIAL AND METHODS

Réunion is an island in the Mascarene archipelago, with Mauritius and Rodrigues, located at 21°06'S and 55°33'E, 690 km east of Madagascar (Fig. 1). Of volcanic origin, these three recent oceanic islands (between 1.5 and 8 million years for the oldest) have undergone various transformations following successive eruptive phases. The Réunion coastline is characterized by a narrow insular shelf and fringing coral reefs developed discontinuously over 25 km (about 12% of the coastline). The northern part, relatively sub-

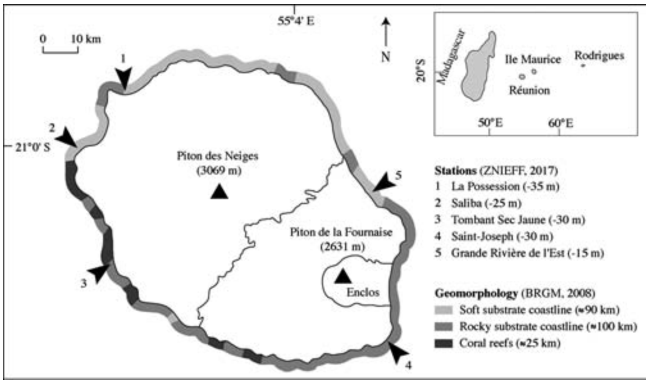

Figure 1. – Location of the observation stations of the 5 fish species presented in this study on a geomorphological map of the Reunionese coastline.

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Cybium 2018, 42(4): 386-390. doi: 10.26028/cybium/2018-424-013

tracted from the effects of the trade winds, receives the majority of the mouths of the 13 perennial rivers and is characterized by more turbid littoral waters, a wider insular shelf and a high proportion of soft bottoms (Pinault *et al.*, 2013b).

The specimens described in this study were observed and photographed during a sampling survey conducted by underwater visual census (UVC) method between 2 November 2015 and 20 December 2017 on many reef and non-reef habitats of the island presenting an ecological interest (> 60 stations). The method of investigation consisted in counting on each station all the fish species observed during 30 min dives, along random courses equivalent to an area of approximately 600 m^2. These courses were carried out at fixed depths (± 5 m), between 0 and 30 m.

The photographed specimens were described following Heemstra (1986a, b), Myers (1991), Smith (1997), Kuiter and Tonozuka (2001) and Allen and Erdmann (2012). Species were classified following Eschmeyer *et al*. (2018). The visual overestimate of the fish total length (TL), due to the modification of the vision in scuba diving (increasing object length), was adjusted according to Edgar *et al*. (2004). Despite this adjustment, a confidence interval of ± 10%, due to the diver approximation, can be considered in the TL estimate. Proportional body measurements were recorded *ex post*, on photographic basis, to calculate standard length (SL), head length (HL), snout length (SN), orbit diameter (OD) and body depth (BD).

RESULTS

Fusigobius inframaculatus (Randall, 1994)

ZNIEFF station: Saint-Joseph, Latitude: 21°21’18.54”S, Longitude: 55°47’31.31”E, Depth: 30 m, Date: 8 April 2016, Time: 8:00.

The solitary specimen of inner-spotted sandgoby presented in this study was photographed on the south coast of the island (Saint-Joseph), at the base of an overhanging basalt column. It was laid on volcanic sand composed mainly of olivine, hence the yellow-green colour (Fig. 2), close to the rock, whose crevices offered shelter where it took refuge from the approaching divers.

Its distinctive morphological features (Tab. I) included a semi-translucent body covered with numerous small orange spots, extending from the head to the dorsal and caudal fins. Five large blackish internal spots and seven rectangular white spots were distributed on each lateral face along a discontinuous line. The first two dorsal spines were elongated and had a white colour at the tip. The gill openings were situated below the posterior half of the operculum, and the caudal fin was rounded.

Fusigobius neophytus (Günther, 1877)

ZNIEFF station: Saliba, Latitude: 21°1’16.32”S, Longitude: 55°13’31.84”E, Depth: 25 m, Date: 22 November 2017, Time: 9:00.

The solitary specimen of common fusegoby described in this work (Fig. 3) was photographed on a sandy patch composed of coarse sediments of bioclastic origin (mainly corals and mollusc shells) at Saliba, off Boucan Canot (west coast of the island). This site is characterized by an alternation of soft sediments and prehistoric lava flows, forming in some places arches and caves partially colonized by corals. The mimetic behaviour of the photographed specimen made it almost invisible.

The distinctive morphological features of the species, observed on the photographed specimen (Tab. II), included a black spot located between the first two dorsal spines (upper half). The body was grey, semi-translucent, with small brown spots extending from the head to the base of the caudal fin. An alternation of small brown and white spots was also visible along a lateral line, ending at the base of the caudal fin with a darker, rounder brown spot. The opening of the gills, very little visible, was located almost below the rear edge of the operculum.

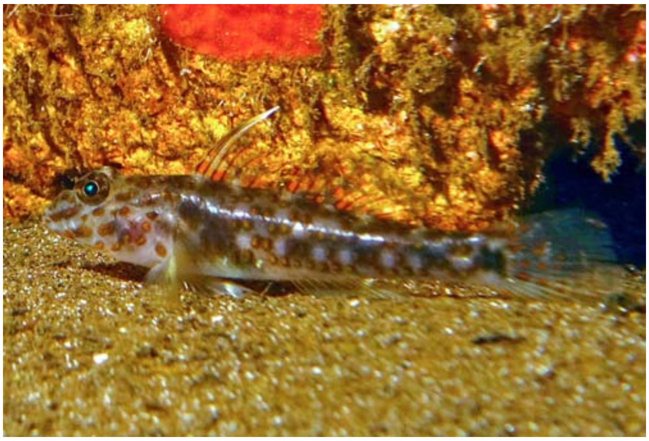

Figure 2. – Specimen of *Fusigobius inframaculatus* photographed on 8 April 2016 at 21°21’18.54”S and 55°47’31.31”E.

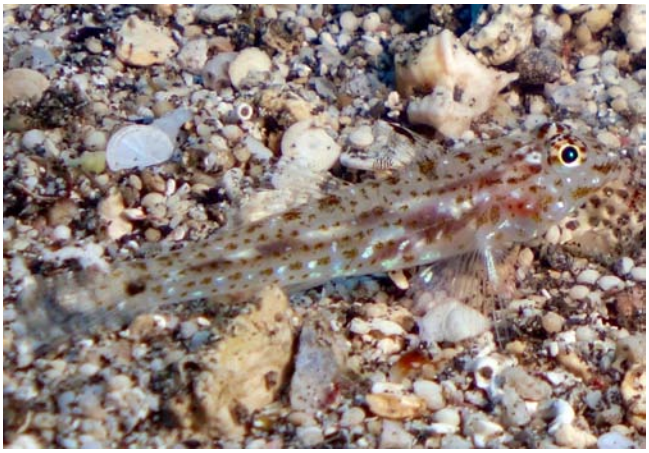

Figure 3. – Specimen of *Fusigobius neophytus* photographed on 22 November 2017 at 21°1’16.32”S and 55°13’31.84”E.

Table I. – Measurements of the specimen of *Fusigobius inframaculatus*; values are given in cm and in percentage of the standard length.

Measurements	cm	% of SL
TL	7.0	–
SL	5.6	–
HL	1.5	26.3
SN	0.4	6.9
OD	0.4	7.5
BD	1.1	20.0

Table II. – Measurements of the specimen of *Fusigobius neophytus*; values are given in cm and in percentage of the standard length.

Measurements	cm	% of SL
TL	7.5	–
SL	6.3	–
HL	1.5	24.4
SN	0.4	6.0
OD	0.5	8.4
BD	1.4	21.6

Samariscus triocellatus Woods, 1960

ZNIEFF station: Grande Rivière de l’Est, Latitude: 21°6’20.92”S, Longitude: 55°46’16.72”E, Depth: 15 m, Date: 4 May 2016, Time: 8:00.

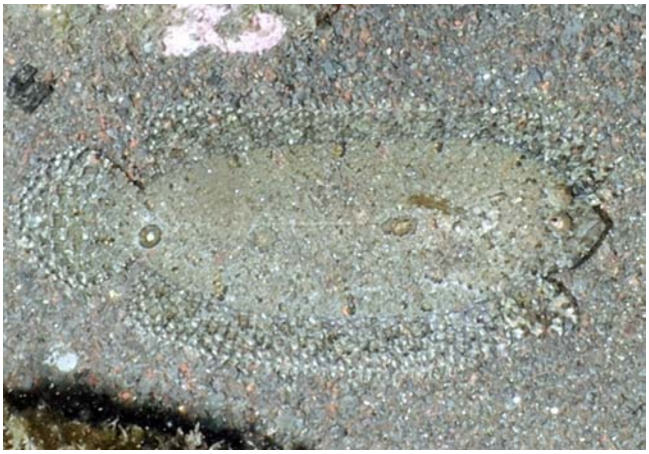

Figure 4. – Specimen of *Samariscus triocellatus* photographed on 4 May 2016 at 21°6’20.92”S and 55°46’16.72”E.

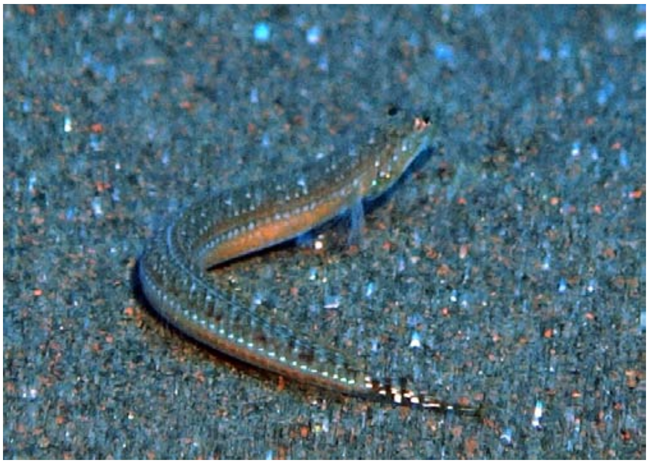

Figure 5. – Specimen of *Trichonotus marleyi* photographed on 6 April 2017 at 20°55’30.54”S and 55°17’55.32”E.

Table III. – Measurements of the specimen of *Samariscus triocellatus*; values are given in cm and in percentage of the standard length.

Measurements	cm	% of SL
TL	11.0	–
SL	8.8	–
HL	2.2	25.0
SN	0.7	7.5
OD	0.4	5.0
BD	3.3	37.5

Table IV. – Measurements of the specimen of *Trichonotus marleyi*; values are given in cm and in percentage of the standard length.

Measurements	cm	% of SL
TL	17.0	–
SL	15.0	–
HL	2.7	18.1
SN	1.1	7.3
OD	0.5	3.4
BD	1.0	6.8

The solitary specimen of three-spot righteye flounder, shown in figure 4, was photographed in the littoral zone of the alluvial cone of one of the largest perennial rivers on the island: the “Rivière de l’Est”. It was placed on a narrow groove of volcanic sediment deposited between pebbles of alluvial origin of several decimetres in diameter. The mimetic behaviour of the specimen made it almost invisible.

The observed morphological characters confirm that it is the species *Samariscus triocellatus* (Tab. III). The photographed specimen had a mottled body of brown with irregular dark and pale markings, perfectly mimicking the colour of the sediment. Three ocelli with black edges were more or less visible along the lateral line and the distal part of the pectoral fin was brownish.

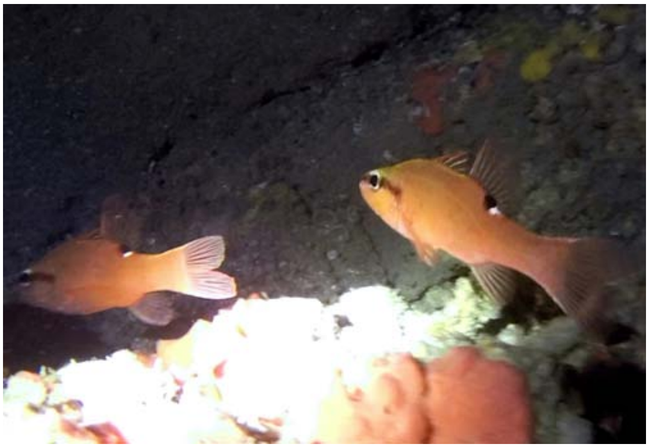

Figure 6. – Specimen of *Zapogon evermanni* photographed on 29 November 2017 at 21°12’20.63”S and 55°16’50.92”E.

Table V. – Measurements of the specimen of *Zapogon evermanni*; values are given in cm and in percentage of the standard length.

Measurements	cm	% of SL
TL	11.0	–
SL	9.1	–
HL	2.3	24.6
SN	0.6	6.6
OD	0.6	6.6
BD	2.0	21.4

Trichonotus marleyi **(Smith, 1936)**

ZNIEFF station: La Possession, Latitude: 20°55’30.54”S, Longitude: 55°17’55.32”E, Depth: 35 m, Date: 6 April 2017, Time: 10:00.

The specimen of Marley’s sand diver presented in this study (Fig. 5) was photographed on a volcanic sand slope in the northwest of the island (La Possession). It was part of a relatively large, but sparse population (a few individuals per 100 m^2), observed from 30 m depth, up to 40 m. The individuals were extremely fearful, burying themselves into the sediment at the slightest alert occurring within a radius of 10 m, making their photography particularly difficult.

In spite of the poor quality of the photograph presented in this study, the morphological characters determining the *Trichonotus marleyi* species are visible (Tab. IV). Thus, the dorsal surface of the specimen, of copper-brown colour, was covered with small turquoise-blue spots, interspersed with smaller, sparser brown-red spots. Small turquoise-blue spots formed a very regular dotted line on the lateral side of the body, extending from the head to the base of the caudal fin. The latter presented a kind of very dark-brown and white checkerboard. The ventral surface was pale pink.

Zapogon evermanni **(Jordan and Snyder, 1904)**

ZNIEFF station: Tombant Sec Jaune, Latitude: 21°12’20.63”S, Longitude: 55°16’50.92”E, Depth: 30 m, Date: 29 November 2017, Time: 9:30.

Evermann's cardinalfish has been observed in a loose group of about ten individuals (Fig. 6), at the bottom of a narrow cave about 10 m long, located about 30 m deep. These individuals, probably dazzled by the beam of the diving lighthouse, were almost motionless. The observation station, known for its many caves and overhangs, was located on the littoral of Saint-Leu, southwest of the island.

The characteristic morphology of this species confirms its identification (Tab. V). The photographed specimens had a reddish-brown body, relatively elongated for cardinalfish. A black band barred the eye laterally. A black spot was visible at the base of the last rays of the dorsal fin and a white spot was visible on the dorsal midline just behind the second dorsal fin. The caudal fin was indented.

DISCUSSION

UVCs are non-destructive, fishery-independent methods and therefore far superior to destructive collection techniques, especially in sensitive areas (Harmelin-Vivien *et al.*, 1985). Although this method of identification is less reliable than DNA-barcoding performed on collected specimens (Hubert *et al.*, 2012), the morphological description of the photographed specimens presented in this study allowed their identification with a relatively high level of confidence. This confidence is based in particular on the quality of certain photographs, on the very characteristic morphological criteria of certain species, on the number of photographs taken of each specimen, of which only the clearest are presented in this study, and on the excellent quality and the abundance of literature relating to the description of Indo-West Pacific species (Heemstra, 1986a, b; Myers, 1991; Smith, 1997; Kuiter and Tonozuka, 2001; Allen and Erdmann, 2012). It may then seem surprising that the identification of these species, presenting no particular difficulty, appears as late in the scientific literature on the ichthyofauna of Reunion.

However, these results confirm the observations of Pinault *et al.* (2013a; 2015b) who noticed, following the Biolave campaign, carried out in 2011 on the Piton de la Fournaise lava flows, that a targeted sampling effort on the less studied habitats of the island still allowed the new record of many species and certain behaviours specific to these habitats, sometimes not observed in reef habitats. Thus, among the five species presented in this study, *Samariscus triocellatus* was observed in an estuarine zone; *Fusigobius inframaculatus* and *F. neophytus* were found on patches of coarse sand, close to prehistoric lava flows, *Zapogon evermanni* was hidden in the bottom of a cave and *Trichonotus marleyi* was photographed in a sedimentary plain. None of these species were recorded on reef habitats, although sampled with the same effort as non-reef habitats (Fig. 1).

In addition, some of these species were observed at depths still relatively unexplored in scuba diving (> 25 m) and exhibited mimetic behaviours, making them virtually undetectable in scuba diving (small size, translucent body). Their behaviour was for the most part extremely cautious with regard to external dangers, making them particularly difficult to photograph. Finally, while most of the species presented in this study have a large Indo-Pacific distribution, *Trichonotus marleyi* has, until now, only been recorded from South Africa and Mozambique to southern Madagascar (Eschmeyer *et al.*, 2018). This new record therefore represents a range extension towards the east of this rarely observed species (Heemstra, 1986a).

It is therefore likely that the continuation of projects describing the biodiversity of non-reef or deep habitats on Réunion Island will allow, in the future, the record and probably the discovery of new species.

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